**Notebook, N-05-09-25**

This notebook covers the period September 1905-July 1906. It contains notes by Edison and unidentified experimenters, possibly Alvin D. Caskey and Charles Dally, relative to the electroplating of metals on electrodes for Edison's storage battery. Most of the entries pertain to the use of cobalt and copper; there are also entries for cadmium and antimony. The electroplating experiments found in this book were continued by Caskey in N-06-08-08.2 [not selected]. The front cover is labeled "Sept 26 1905 Caskey. Plating Vol I." The pages are unnumbered. Approximately 200 pages have been used.

Only the material by Edison has been selected.

Plating Machine Record

Firm Sept. 25, '05

N-05-09-25

Jany 3rd 1906

Things found out

1st 1st layer 3 min 15 amp for Cop
Subsequt layers 25 am 3/4 min
+ Co 30 amp 1/2 minute, it self peels
after 2 or 3 layers - dividing rod in -
by changing to
1st layer Cop 3 min 15 am
Subsequt layers 1 16 amp 1 1/4 min
+ Co 17 amp 50 sec it Dont peel

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2nd -

At the top of drum if it dont come
to same point or place in the 2 solution
+ Copper plates on copper it sticks
+ cannot be torn apart - therefore, copper
of one layer should never be plated
on the Copper of the next Copper layer
I have not tested if Cobalt sticks to
Cobalt -

3rd

Where there are black streaks its to solution getting between layers, or running down from top or a hole full of it.

4th

Finger marks stains bad plating

5th -

That ruby surface is due to fine layers of gas bubbles -
The Copper under micro will in most cases show innumerable circular depressions over its whole surface, this is due to microscopic bubbles of air or hydrogen -

6

The steel strip is liable to bring solution from one bath to the other also rim on the drum if it hasn't a good fit. a bad fit leaves Caustic

7th

When strips are torn apart you always see copper on one side Cobalt on the other, never Cu & Cu or Co & Co. The reason of this is that when the Cobalt is put in the Copper the solution corrodes it without Current, but when the Cop goes into Cobalt val Cu Cant reduce it, hence the difference.

8

If the Cobalt film is left in the Copper Solution for 1 minute the whole of the Cobalt will be dissolved & go into the Copper Solution -

9

Copper deposited on Cobalt by reduction only makes an absolutely perfect deposit & the Cobalt deposited on it by Current is perfect,

10

The adhesion of copper by reduction is small – the Cobalt deposited at the density we now use & the solution we now use is so great that there is too much self peeling our density is 17 amp 50 sec –
Sulphate? Solution!
Chloride?

11

35 amp on Cobalt with 1½ lead drum is too great a density for the solution used it plates for an instant perfect then nubs reach out to get more Cobalt ions hence build up – 17 density gives good results –

Jan 2nd 1906

Test 199

Lead & Pb drum
Cu 50 Sec @ 6 amps
Co 1 min @ 16 "
5th coat started to break away from steel pin in drum
did not have a chance to try cutting in the groove

Test 11.200

Same as No 199 except cu wire in groove instead of steel pin
5th coat it started to break away from wire

Jan 3-06

Test 201

Used 95+5 with wire in slot

Cu plated 3 min @ .12 amps

Co " 1 " @ .15

This was no good owing to finger marks on drum

Test 202

Used 95+5 with wire in slot

Cu 6 min @ .6 amps

Co 1 " @ .15 "

2nd and following coats

Cu 50 sec @ .6 amps

Co 1 min @ .15

Stripped on 5th Co coat

Test #203

Used drum 95+5 with slot in edges of slot were rounded off with pen knife

Cu 3 min @ .12 amps

Co 1 " @ .14 "

2nd and following coats

Cu 50 sec @ .6 amps

Co 1 min @ .14 "

Continued to 8 coats

Tab stripped by cutting the plate down side of drum not using the slot to strip by

Test 204

Used same drum

Cu 3 min @ .12 amps

Co 1 " @ .14 "

2nd and following coats

Cu 50 sec @ .6 amps

Co 1 min @ .14 "

Continued to 2 coats

Peeled at knife cut after 2nd Co coat.

Jan 3-06

Test #205

Used drum as before except tar smoothed knife cut down with pen knife

Cu 3 min @ 12 amps

Co 1 " @ 14 "

2nd and following coats

Cu 50 sec @ 6 amps

Co 1 min @ 14 "

Continued to 3 coats which began to strip where the knife cut was, owing to not getting it completely smoothed over.

Test 206

Used drum as above after it was redressed.

Cu 3 min @ 12 amps

Co 1 " @

2nd and following coats

Cu 50 sec @ 6 amps

Co 1 min @ 15 "

Continued to 7 coats

Tar tried to strip by rubbing glass rod on side of drum and then taking knife and raising it at the point of rubbing and catching hold with fingers and tearing. Did not work very well.

Test 207

Used 85 + 15 drum without slot.

Cu 3 min @ 12 amps

Co 1 min @ 14 "

Edison 12

Copper got plating bad, it was so thin (with 10 amps which previously produced ok deposit) that it wouldn't self strip

We altered the solution — made no other changes, (how it worked off - probably dirt gets on cylinder by rotating which churns the solution + makes bad spots if they stick to cylinder hence points of weakness + we have self peeling

(10) I think both solutions should be filtered daily

Jan 4th 1906

Test 208

Cu 3 min @ 12 amps
Co 1 " @ 15 "
2nd and following coats
Cu 50 sec. @ 6 amps
Co 1 min @ 15 "
Plate nice and bright
Tried cutting with knife like shaving
Did very well
But plating has not the silk lustre it should have

Test 209

Cu 3 min @ 12 amps
Co 1 " @ 15 "
2nd and following coats
Cu 50 sec @ 11 amps
Co 1 min @ 15 "
tried stripping with needle

Test 210

Cu 3 min @ 11 amps
Co 1 " @ @ 15 "
After plating Co it was allowed to stand in Cu sol 5 sec without current. Did not improve much.

Test 211

Cu 3 min @ 10 amps
Co 1 min @ 15 "
2nd and following coats
Cu 50 sec @ 5 amps
Co 1 min @ 15 "
made Co sol quite acid
Plate has appearance of being much better.

Edison 13 -

I plan
In Cobalt solutions the reason they must be acid is that there is always at high density a tendency to deposit both metal & Hydroxide of the metal
This hydroxide is colloid + deposits metal through it but as the amount of Cobalt solution in the cloth of hydrate is small the deposit is enormous, thus a porous deposit which [illegible] out rapidly - [illegible] Thin deposits [illegible]

more hydrate, + we have filaments running out at right angles to the deposit — If we put acid in it dissolves the hydroxide as fast as formed + probably prevents its formation any solvent of hydroxide will answer that the reason Double Ammonium Salts used as Ammonia is a solvent of hydroxide —
Only sufficient acid should be used to counteract the tendency to deposit hydroxide —

At 6 P.M. added 15 drops of HCl to Co. sol. it was previously almost neutral —
The addition of acid made the sheets flexible + stripped the black filaments but not altogether the round rubs —

Edison 14

To stop peeling insulating varnish must be on both ends of in the solution –
To stop peeling in the intermediate space be sure there is no bad spots where it dont plate as it starts to tear at these points –

This way gives sheets all of which can be split whole & do not stick together & will go ok if can get rid of self peeling after 3 or four layers

From Copper plated thick polished –
then Cobalt plated thick & polished –
Then
14 Layers of a batch: 2½ amp 2 minutes in strongest Copper Sulphate (acid) –
Subsequent layers 2½ amp one minute.
Cobalt 15 amp 100 seconds
This is plating from a plain Chloride Co Solution 1.080 Spec Grav –

Jan 6 - 06

Test #212

Used Co plated drum
Solution #13
Cu plated 4 min @ 3½ Amps
Co " 2 " @ 12 "
2nd and following coats
Cu 4 min @ 2½ Amps
Co 2 " @ 12 "
Cu plating is very red.
Co plate appears dull, due
to the red copper

Jan 8-06

Test 213

Used Co plated drum "
Solution #1
Cu 2 min @ 7 amps
Co 1 " @ 15 "
Plating stripped after 1st coat
Cu plate appeared to be coated
with a white film

Test 214

Solution #3
Cu 2 min @ 7 amps
Co 2 " @ 12 "
2nd and following coats
Cu 2 min @ 2½ amps
Co 2 " @ 12 "
Co plate is very dark
Cu " is much better than
#213
Plating adheres to drum and
wear nicely.

Jan 8-06

Test 215.
Used Co plated drum
Solution # 3
Add 15 drops HCl to Co sol.
Cu 4 min @ 7 amps
Co 2 " @ 12 "
2nd and following coats
Cu 2 min @ 2½ amps
Co 2 " @ 12 "
Co plate appears much better
Cu plate appears very homogenous
1st coat stuck to drum sol.

Test #216
Used Co drum Sol #2
Cu 4 min @ 7 amps
Co 2 " @ 12 "
2nd and following coats
Cu 2 min @ 5 amps
Co 2 " @ 12 "
Did not adhere to drum very
bad but layers did not seem
to be separate

Test 217
Used Co drum
Solution #2 ½ strength
Cu plated 4 min @ 7 amps
Co 2 min @ 12 amps
2nd and following coats
Cu 2 min @ 5 amps
Co 2 " @ 12 "
stripped very good in places.

Test 218
Used Co drum
Solution ~~#2~~ ½ strength
Before using Co sol it was made
neutral by adding Co(OH)2 and
filtering, Anodes also were scrubbed
Cu plated 4 min @ 7 amps
Co 2 min @ 12 amps
2nd and following coats
Cu 2 min @ 5 amps
Co 2 " @ 12 "
although Co plated to become
self coated with Cu before putting
in current
Co plate was fine and bright
By adding the Co(OH)2 it

218 Cont

have removed some of the Jts.

$CoCl_2$ Sol 1090 plate too galvanic
+ brittle self peels before can get
1st Eq Coat on Copper –

219

Co plated drum:
$CuSO_4$ 1190 10cc acid –
1st Coat 2½ amp 8 minutes
Subsequent Coats 2½ amp 5 minutes
Cobalt – 18 amp – 1 minute
Peels on 1st Coat – Comes off easy
+ Curls up several turns,
Extraordinarily brittle –
I cleaned the drum + then deposited
the 1st layer of Copper & found it
stuck to Cobalt & said drum
perfectly tight so it was impossible
to peel any off even 1/32 after 1
Coat Co put on
I then plated copper on the Eq Co
Cylinder surface + then
put it in Cobalt ~~[illegible]~~ 6 amp
for 3 minutes using a Carbon
Electrode + disconnected the Co
Anode – The plating was
not shiny but irregular soft
+ not shiny + the 6 sheets were
quite flexible – While plating
I noticed strong Ozone +
as I only used the Carbon Electrode
on the 1st Co plating + not

afterward — The ozone smell in the liquid continues during the peeling of the other coats — after 1/2 hour it is still strong — It seems to dissolve in the liquid — Possibly it peroxidizes the $KClO_3$ — this keeps decomposing giving off Ozone — The effect at any rate of the ozone is to cause a non glassy shining deposit which isn't spongy — This is probably due to the ozone continuously reducing the Hydrogen & preventing it from depositing with the metal. Hydrogen is supposed to make metals brittle. 3 minutes at 6 amperes probably makes more ozone than is necessary. 1 minute at 6 amp would probably do for 2 or 3 hours. Possibly a small Carbon Electrode could be connected to the Pt anodes so as to form the right amount of Ozone to take care of the Hydrogen. Even Chlorine water might answer. — If a Carbon Electrode

is used I guess 1% of the total
anode surface would be
sufficient —
The same effect could be
produced with Copper if a
Chloride was used $CuCl_2$
or $CuCl_2$ in salt solution
plated 2 Copper Cylinders
12 amp 30 hrs + the Ozone
still is effective —
plated 2 or 3 Cylinders full
Co layers. The Co plating
is not shiny but its perfect
fine grain no holes or sheet
effect coming off is flat
Can split them all but they
stick hard together yet pull
apart — The 1st layer comes
off perfect and 1/2 the
cylinder the other 1/2 sticks
partially due to bad
places on Cylinder — if could
get more margin in stripping
think should be OK —
Evidently Ozone or something
to take care of the Hydrogen
is necessary — The reason

~~Ga~~ plating good

| | | | |
|---|---|---|---|
| 1st Layer Copper | 12 amp | 2 | min |
| other Copper layers | 12 amp | 1 | min |
| Cobalt | 18 | 1 | min |

We got good plating before at tips was that anodes got coated + somewhat insulated + this reduced the surface so much that at the density used the carbon particles permitted Chlorine to be given off + thus either acted as oxidizer or Ozone formed — When anodes cleaned there was no free Chlorine or Ozone hence the deposit became bright + brittle from absorption of hydrogen —

Jan 9-06

Test 220

Used Co drum
Solution + 14 Cu
Cu 2 min @ 12 amps
Co 1 " @ 18 "
2nd and following coats
Cu 1 min @ 12 amps
Co 1 " @ 18 "
Plated 5 coats
Cored not strip
Cu plate was red and a
white film over it
Co dark owing to above

Test 221

Used Co drum
Solution + 8 Cu
Cu 2 min @ 12 amps
Co 1 " @ 18 "
2nd and following coats
Cu 1 min @ 12 amps
Co 1 " @ 18 "
Plated 2 coats Plate very rough

Test 222

Co plated drum
Solution #8 made alkaline by $NH_4OH$
Cu to co plated as in 221
Strips well from drum

Copper is not reduced by Cobalt
in a Solution of Double
Sulphate of Copper & ammonia
with free ammonia.
Sheet strips well.

Test 223

Co plated drum same as # 222 except
Solution #8 made alkaline by $NH_4OH$
used for 1st Cu coat subsequent
coats used # 2 Cu.

Jan 18-06

Test 224

Used Co plated drum
Solution #16 Cu Reg Co Sol
Cu plated 2 min @ 12 amps
Co " 1 " @ 18 "
2nd and following coats to 10
Cu 1 min @ 12 amps
Co 1 " @ 18 "
Plate a little rough
But stripped from drum fine
Duplicated this 3 times and
all came off without any
trouble

Test 225

Co drum Solution #16 Cu
Cu 2 min @ 8 amps
Co 1 " @ 18 "
2nd and following coats to 5
Cu 1 min @ 8 amps
Co 1 " @ 18 "
Plate still rough but does
not adhere to drum

Jan 10-06

Test 226

Solution 16 Cu Co drum
Cu plated 2 min @ 6 amps
Co " 1 " @ 18 "
2nd and following coats to 5
Cu 1 min @ 6 amps
Co 1 " @ 18 "
Plate still very rough
Probably due to the crystallization
of the salt on anodes and jars

Test 227

Co drum Sol 16 Cu poured off
from crystals in jar of 226
and 10% water added
Cu plated 2 min @ 6 amps
Co " 1 " @ 18 "
2nd and following coats to 7
Cu 1 min @ 6 amps
Co 1 " @ 18 "
This adhered to drum very bad.

Jan 10-06

Test 2-28

Co drum Solution #16 Cu with made
~~acid~~ 10 drops $H_2SO_4$ added
Cu plated 4 min @ 6 amps
Co " 1 " @ 18 "
2nd and following wash.
Cu 1 min @ 6 amps
Co 1 " @ 18 "
2nd wash 1 very rough.

Test 2-29

Co drum Solution #16 Cu made
alkaline with $NH_4OH$ full strength
Cu plated 4 min @ 6 amps
no deposit.
Made another 4 min but
still no deposit

Jan 10-06.

Test 230.

Co drum Solution #16 Cu made alkaline by $NH_4OH$ diluted 1/2.
Cu plated 4 min @ 6 amps
Co " 1 " @ 18 "
2nd and following coats
cu 1 min @ 6 amps
Co 1 " @ 18 "
Plated 7 coats
The appearance under micro much better but still a little rough. - stripped fine and drum still retains its high polish, which indicates no reducing action on the Co in this solution

Test 231

Co drum Solution #16 Cu which had been made alkaline by $NH_4OH$ has not been made acid by $H_2SO_4$ and diluted to 1/2 strength.
Cu 4 min @ 6 amps.
Plate was as though it was burnt and appeared pulverulent in places.

Test 232

Co drum same oil as 231 except it has been made decidly acid.

Cu plated 4 min @ 6 amps
Co " 1 " @ 18 "

2nd and following coats
Cu 1 min @ 6 amps
Co 1 " @ 18 "

3 coats rough as the [illegible]

Test 233

Co drum same oil as 232 but it has been filtered

Cu plated 8 min @ 3 amps
Co " 1 " @ 18 "

2nd and following coats
Cu 1 min @ 3 amps
Co 1 " @ 18 "

10 coats

Jan 10-06

234 = diluted 232 1/2 - Nq - added
lot Sulphate ammonia & used 6 amp
Nq - Threw it away

235 No 10 Solution 20 drops Chlorine
Water in ~~[illegible]~~ CoCact solution on
234 = plated No 10 just as it is
2 cc acid =
It stuck rather bad - deposit wanty

236 - Started Copper on first
Coat with One amp and for 10
Seconds then put on 12 amp 2 min
Subsequent deposits 12 Cu 1 min
Co 1 - 1 min - did not stick
Came off in perfect sheet - Deposit
Wanty

237 - Same as 236 Except filtered
the CoCact Solution - full of
fine black floating particles.
Thought perhaps this gave the
wanty surface - It stripped perfect
but was not as wanty Evidently do
goo or Chemistry pbly goo

Jan 10-06

238 – Same as 237 but with 100 drops Chlorine water, after stirring could just smell the Ozone smell – current rate same as 236 – The blues are nearly gone – strips fine – Evidently the Chlorine removes the hydrogen Evidently –

239 – Added 100 drops more of Chlorine water – Strips perfect, Waste still less – a little more Chlorine would prob do the Ozone –

240 added 100 drops more of Cl water still less waste. strips good.

241 added 100 drops more of Cl water still less waste strips perfectly

242 Added 100 drops more Cl water still improving strips perfectly

243 Added 100 drops more Cl water surface about the same @ 242

Jan 11-06

Test 244

Co plated drum Solution #10
Cu plated 2 min @ 12 amps
Co " 1 " @ 18 "
2nd and following coats
Cu 1 min @ 12 amps
Co 1 " @ 18 "
Plated to 10 coats very fine
Stuffed perfectly
Duplicated 3 times all good

Test 246

Same as 244 but for
Endurance.
Continued to 20 coats
Not so very bad

Jan 22-06

Test 246

Took some of solution from work that would not plate right on large drum and purified it by peroxidizing with $H_2O_2$ and boiling with Co $(OH)_2$

Cu plated Co drum 2 min @ 2 amp
Co 1 min @ 18 amps
2nd and following coats
Cu 1 min @ 12 amps
Co 1 " @ 18 "
The above sol after purifying was diluted to 1053 Sp Gr and 20 CC of Saturated Bromine water was added.
Used Cu sol just as made up for large drum
Plated 10 coats was nice and bright but very brittle, indicating too much Hydrogen.

Test 247

Same as 246 except added 10 CC more of Bromine water to Cobalt Sol. very bright & stuck

Test 248

Cu plated drum 10 min @ 2 amps then 2 min @ 12 amps
Co 1 min @ 18 "
2nd and following coats
Cu 1 min @ 12 amps
Co 1 " @ 18 "
Add 10 CC more Bromine Water
Stripped bad

Test 249

Cu plated same @ 248
Add 10 CC more Bromine water
Stripped better but a little rough

Test 250

Add 10 CC more Bromine water
very rough

Test 251

Now using reg. Co plating sol.
and Cu plating sol from Impetaire
Add 10 cc Bromide water to Cu sol
Cu plated 2 min @ 12 amps
Co " 1 " " 18 "
2nd and following coats
Cu 1 min @ 12 amps
Co " " @ 18 "
Plated 2 coats
2 coat of cu began to burn

Test 252

Same as ~~above~~ 251 except
1st coat Cu .4 min @ 6 amps
Co 1 min @ 18 amps
2nd and subsequent coats Cu
2 min @ 6 amps

Test 253

Add 10 ~~cc~~ mg Bromine water to Cu Sol.

1st Coat 10 sec at 5 amps then 2 min @ 1.2 amps

Subsequent coats 1 min @ 1.2 amps

Co 1 min at 1.8 amps

Test 254

Got fresh Cu Sol from crock

add 10 CC of Cl water

Cu plated 10 sec at 3 amps

Then 2 min @ 1.2 amps

Subsequent coats

Cu 1 min @ 1.2 amps

Co 1 " @ 1.8 "

Continued to 10 coats,

Came off very good.

Jan 22-06

Test 255

Make up of Cu of the Bromine sol to 1.070 the same as reg Co

The old Co solution that we had several days ago the Carbon Electrode works OK but the solution we had up then that failed & stuck to drum wouldn't work it was to shiny & brittle stuck to drum - got rough a few while - We put 70 cc Saturated Bromine Water in - It plated just as shiny & was brittle -

We now take the same solution & put Carbon anode (electric arc Carbon) 3 minutes 4 amperes The Co plating is dark on 1st Coat - liquid smells strong of Cl or Ozone - 10 layers plating OK the good dull appearance & smooth no waste to the eye - The final layer of Copper stuck to the drum - Evidently the Copper

needs the same ozone or therefore
be more selfred action of Copper
by the bath Cobalt dream so it
will not attack
We are duplicating it with
same Copper sol & Co solution
after the latter has been used
for 10 layers - its still dull Co.
2nd 10 layers came off good -
I notice that the layers cannot be
split -
The 3rd Trial same Cobalt
Same Copper except about 10 or
15 CC $H_2O_2$ added to peroxidize
the Iron with the Copper to see if
this prevents the final Coat
flaking on Chiselling heat &
also Experiment splitting Coats
Co plated dull - good,
Copper good - The 10 layers came
off perfect - Plating on 10th
layer on Cobalt very good fine
grain - There was some warts
but not close together -
Could not split sheets -
This plating would be off
if splitting off sheets is not

necessary think 15 coats or
Even 20 would be practicable
as far as plating is concerned —
Evidently peroxidizing the Copper
Solution by $H_2O_2$ is a good
thing. Think warts may be
due to air or float stuff in
liquid —

One thing is certain that
Dull Cobalt plating is necessary
to prevent brittle self cracking
flaking — + this so far is
best attained by Bromine water
+ I think not Chlorine but is
attained by a Carbon Anode
4 amp — 3 minutes in Cobalt
Solution while drum is being
plated — but it shows up bad
on the 2nd Drum —
Possibly $H_2O_2$ will do as well

Also this treatment will
last for several Drums of
10 Each + how much longer
not known —

We now have the same Copper
Solution with the $H_2O_2$ put in on
3rd Drum trial —
The Cobalt is a new solution
from big Crock upstairs
which dont plate right as it
plates bright on brittle
Into this Solution I stir
10 CC of $H_2O_2$ to see if $H_2O_2$
is a substitute for the Carbon
Electrode Chlorine Ozone —
The 1st Coat of Cobalt was
bright so I added immediately
10 CC more of $H_2O_2$
This brought the 2nd layer of
Cobalt quite dark darker
than it showed 6x, probably got
too much in - on plating the
with Copper it was all brown
and it washed away (12) both
the Cobalt & the Copper plated
Red like over it — I now put
it back in the Cobalt to
see if it plates — it plates
the right Color - Lead Color OK -
The next Copper plates red
probably because the Cobalt

is oxidized - Evidently only
Enough $H_2O_2$ to peroxidize the
Iron & Can be used any excess
oxidizing the Cobalt
Had to give this Drum up -

Allow the Cobalt Solution to
rest 10 minutes to use up
some of the $H_2O_2$ & Start a
fresh drum - Its no use -
Copper got red on 2nd Coat
I wait 10 minutes more
& try =

1st Coat on Cop dark blackish
2nd Coat Copper Red - Strip
right off showing Cobalt
replated on oxidized -
Too much $H_2O_2$ in Cobalt
Solution

Another attempt -
Co dark blackish Copper -
Red all came off nicely
in Cu Solution

Filtered the $H_2O_2$ Copper Sol.

The put Coat Copper on Reg way - then put in the Cobalt Solution we have been using that has the 20 cc $H_2O_2$ & used Carbon anode 4 amp 3 minutes.

1st Coat Cobalt bright.
2nd Coat part bright part streaky dull, next Coat Copper ok in places Red & spongy in others

Another attempt start fresh & pass 4 amp 3 minutes again through the solution perhaps want this to neutralize the $H_2O_2$ = 1st Coat Lead Color fine 2nd Copper Coat ok = 2nd Co Coat good Lead Color - 3rd Coat Copper ok - 3rd Coat Cobalt ok guess all are ok The Chlorine gas

Evidently neutralized the $H_2O_2$ & then the Extra dose brought the Solution up OK —
Sheet came off OK Except one small spot this stuck hard — This shows that the kind of Polish & surface must be Experimented with,
There were some small warts but not Enough to harm but still more than there should be = The cause of of these warts must be ascertained before we are sure of permanent results,

Same Solutions (1c) Cobalt with 20 cc $H_2O_2$ thence twice with Carbon anode 4 amp — 1 min Each time Copper 10cc $H_2O_2$ I now put in 20 CC more $H_2O_2$ making altogether 20 CC of $H_2O_2$ in the Copper Solution,

1st Cobalt Lead Color rather blush with a bright streak at bottom, 9th streaky - Color ok - the Copper dont seem be streaky only the Cobalt to req good Lead Color + then finish brighter streaks - The 4th Coat Cobalt is not so streaky - 5 Coat Cobalt still less streaky - 6th Co Coat streaks nearly gone - good Lead Color - 9 Coats pretty good stripped ok except in one place -

Noticed Phenomena - The first layer bright side of Copper (when sheet stripped) coff had warts on extending outward on looking at Cylinder found it pitted bad over, The primary Coating is pitted so you can put Drum under Micro + look down into the holes see the original Copper - I discarded this Drum

I notice that even the best ones are pitted but some although pitted do not extend very deep. I believe this is the cause of Warts & also difficult spots where sheet sticks to drum —

We make another trial — same Copper Solution which has 20 cc $H_2O_2$ & put in 10 cc of Chlorine water — The Cobalt Sol is from upstairs that was treated with $H_2O_2$ 20 cc & then twice with Carbonate. The Drum is fair & has few pits. 1st Coat Cobalt very streaky part of streaks are Lead Color & the other streaks are brighter than the right Color. When the Copper plates over the Cobalt streaks the Copper is bright where streaks are bright & not so bright but OK where Co is dead Color. 6th Coat Co not very streaky they have almost disappeared

good Lead Color — good
Copper plating —
The Co Coating 80% of the
sheets disappeared almost
uniform Lead Color — Remember
this is a good drum.
Come off all but stuck in spots
upon investigating found the trouble
is holes in the Original Cobalt
base —

Found that all our drums have
lots of holes & I think this is
trouble of sheets sticking along
the Canal of stuck as liquid
gets in these holes & if water
gradually goes out or retaining
& keeps Co. from touching or
rather dilutes & make spongy
plating — also, as we pack
the cylinders more holes are
uncovered, some just the top opens
& shows small hole & on further
polishing it gets bigger as
the original hole is due to a
bubble or a dirt spot on the
Copper

It is going to be very essential that the base coat of Cobalt must be free of bubbles, holes etc & there is going to be a very difficult thing to accomplish

Using the same solutions as last used (10) the Cobalt which is from upstairs & had 20 CC $H_2O_2$ & two applications of Carbon anode — We plated a Copper drum with 4 amperes one hour. The coating is fine but there are several places which show which opals under the microscope they are slight irregular depressions 4 or 5 times the diameter of a bubble hole. There is no hole to be seen but undoubtedly it indicates a hole underneath which in polishing will be brought out to start with. There are probably more than 50 of these opals — The general plating is very fine —

We now start plating with the Copper solution that had 20 cc $H_2O_2$ + afterwards 10 cc Chlorine Water + the Cobalt 20 cc $H_2O_2$ + twice Carbon anode 4 amp 3 min each time with the newly plated Cylinder

1st Coating Cobalt streaky Lead color & brighter – I can't make out what causes those streaks to stop them we rotated the Cylinder as it passed out. We Cobalt solution but this didn't stop streaks possibly the streaks are due to the Copper getting with the Chlorine in but I don't think so. – 6th Coat Cobalt streaks are gradually disappearing approaching a uniform Lead Color – 8th Cobalt uniform Lead Color Came off – but streak in many places especially the holes also in places where there were no holes – where streaks

1st appeared - There must be no streaks on the 1st Coat of Cobalt

We are now going to clean the drum by pumping Rinse with Water and then use drum as a Cathode in 10% KOH using the same Co & Copper Solutions we have been using -
By mistake we put the drum in KOH as Anode
Thought we would try it that way - put on only 1 Co Coat it was very streaky - It stripped fine probably because Co was oxidized by being anode in KOH has a lead colored tinge showing slight oxdn. This may be just what wanted for the 1st Coat,
Thinking that the Cobalt

so full of specs we filter
& found it so - Will try
again & see if filtering
stops the streaks if that
Lucke gave it another
Carbon anode again —
filtering didn't cure the
streaks on 2nd Co Coat.
I put in Carbon 4 amp 3 mm
the Coat was fine - Even dead
Color — little brighter than usual

Therefore streaks are due
to something neutralized by
the Effects of the Carbon
Anode. Chlorine Ozone etc,

3rd Coat Cobalt fine,
Stripped perfect inside & Copper dull
not shiny as here before, because
primary load of Co is exhausted
by 6 amp anode — KOH 10%
used 12 amp 15 seconds — KOH

Jan 23-06

I think this will always permit stripping

The Cobalt Solution lost its grading about 2 hours after application of Carbon Anode.

#257

Took drum plated 1½ hrs @ 4 amps
Punised it and treated as cathode in KOH 15 sec at 12 amps
Then put rubber band at both ends of drum to see if it would help in stripping the wax off.
The Band are of great service at the ends as it saves the cutting of the plating - but it seems to have a tendency to build up and become rubby for a distance of ¼ inch from bands. This will do no harm as it can be trimed off before final cutting up.
During this test the Carbon Anode was used again 3 min @ 4 amp stripped perfect.

Jan 23-06.

Test 258

Took another drum and treated it as cathode for 15 sec at 20 amps then washed and plated Cu at 5 amps for 10 sec then 2 min at 12 amps in the Cu sol which was used during night of 22nd

Subsequent coats of Cu are 1 min at 12 amps

Co sol same as used this morning

Co plating has the usual dull appearance - This drum has the rubber bands at top and bottom

After a few coats ~~on~~ on the rubber bands become coated

Continued to 10 coats

Comes off perfect, some warts

Can't notice any made or warts on 1st Layer Copper

Have plated 15 amp hours since using Carbon - (13) 1 prime Coat Co 4 amp 1½ hours & 27 Coats 15 amp 1 min

Total 1 amp for 15 hours -

1500 cc Solution - This melts 260 with addition 3 layers more

Jan 23-06 Test 259

Tested a smooth drum in
KOH 15 sec at 12 amps as anode
washed thoroughly and plated
Cu 10 sec at 5 amps then
3 min at 12 amps
Rubber bands at top and bottom
Subsequent coats of Cu are
1 min at 12 amps
Plate has bright appearance
Comes off perfect under Copper
than 258 = which is due to anoding
the primary Cobalt surface
Blade mirror warts on last layer
than 258 — no warts on 1st layer
Copper made — 258 & 259 —
Primary Coat Co 4 amps 1½ hour
.28" Surface Bypass. 7 inches
to Copper — ~~Original Copper~~
~~buffed~~ Original Copper not buffed
but Cobalt surface was buffed.

Jan 23 06

Test #260

Used drum which the cu was buffed then plated 1 1/4 hrs @ 4 amps in Cs sol then buffed again Tested as cathode in KOH for 15 sec at 20 amps then thoroughly washed (no pumice) and Cu plated 10 sec at 5 amps then 2 min at 12 amps Subsequent Cu crate 1 min @ 12 amp, Came off perfect - The drum has original Cop. + Cs buffed - No holes Copper very polished -

Jan 28. 06

Test 261

This drum is used after stripping plating of #260 without any ~~do~~ treating further than dipping in water. The surface had a slightly dull appearance.
Continued to 10 coats
Came off ok except at Edges where it was undoubtedly dirty - it stuck here very bad about 1/8 to 1/4 from each edge — Bubbles few —

This seems to show that we must have Clean drums to start with

I notice that scarcely a wart on 1st Copper none on 1st Cobalt
Then Each section of 2 or 3 layers have more + more warts

Therefore gas is produced on every layer + these starting Oxide buildup —

Test # 262

After stripping plate # 258 off Cathodes in 1 m KOH and plated Cu 10 sec @ 5 amps thin 2 min at 12 amps

Before putting current on when dipping in Co sol the drum was allowed to run 10 sec to allow the thin film of water which adheres to drum after washing to become mixed with the solution so as not to have bubbles form if this is the cause on plating 4th Co the current was put on at 5 amps for 3 sec by mistake before allowing to run any length of time.

Plated 10 coats.

Came off OK except 1 small spot on one Edge where perhaps some Copper was left, usual number of warts

Note we have plated 60 Coats with one full prime plating from Co Solution Total 1 amp for 24 hours without Solution gone bad since last anoding with Carbon Electrode – since this 30 more layers making 9 more amp hours or Total of 33 amp hours. When solution started streaky on 1st Coat, ha treat with Carbon anode –

263 – after stripping 259 – was made anode in KOH & in plating on Cobalt when Cu put in Co allowed to revolve 10 sec before current on – stripped perfect – Copper dull Usual number of warts

264 = Using same Cylinder as 263 without doing anything to it – but re anoding it in KOH – some Co also appeared on copper after 3rd layer. Came off at perfect Copper dull but drum fairly clean – The checks showed that they were Enormously built out warts –

It looks as if warts were due to gas & building out from very small projections in dent spots – This showed be helped by putting anodes 33% further away from the drum

265 = Anoded same Cylinder as used in 263 & 264 again — KOH, 1st layer Copper showed a rough section,
Possibly wrong Cathode drum 1st & then anode it — or only use Cathode, further experiments will prove which has the most Margin —
Jan 24-06
Daily last night plated with same drum as used in 263 which drum was plated with Cobalt 4 amp 1½ hours & showed no pits — Daily plated 4 times 10 layers each. The drum was found pitted — I looked at it this morning & found thousands of holes deep & round clear down to the Copper —
Evidently these holes were in the original plating & the wire burned over by galvaning —
They are Either due to gas or spread on the original Copper surface,

Jan 24-06.

Evidently We must find out how to plate the thick Coat of Cobalt on drum without holes –

Washing the drums in two jars
Ng – 1st jar gets full Copper & Co Salts, the one dark show but undoubtedly has it. Must have a Shower bath for 1st Cleaning then the 2 jars, the last jar to be supplied every drum fresh fresh Water put in –

Notice majority of holes are along a scratch mark in the base, probably in using pumice cloth etc these scratch marks fill with non Conductor + the plating starts bad, also the sharp Edge of the scratch is the place where gas would naturally cling – We shall have to Cathode with a heavy Current to clean these scratches.

Jan 24-06

out by heavy production of Hydrogen —

Possibly as Copper & Cobalt absorb Hydrogen that it passes out of plating & forms microscopic Bubbles

266 = With rather bad drum having some bad pores & holes etc We are trying something new — Used Regular Cobalt Solution that was used yesterday — all thought last night & all day today — But just put Carbon anode in 4 and 3 min. Used new Copper Solution from upstairs which was purified by Cooky & Dr G — not entirely free from nickel — Put in 50 cc of Conc Chlorine water = The first Copper Coat was the most Even & Beautiful we have yet seen — The Cobalt was equally perfect to the Eye —

We tried Experiment of putting Cobalt drum in Cop Sol to see then took out & washed & soaked it in water to get rid of the Co Sol – then put it back in Cop Sol & put Current on Ordinary that Salts left in reduced Co was Carbon gas – results negative no improvement,

We are using Rubber Bands on End Cylinders at first they plated over & were bad. Cookey treated them all night Dry KOH 10% – Now they are O.K. & don't plate over at all – They will be OK for Big Drum –

Evidently putting Chlorine into the Copper to the Extent named makes fine Even plating – the 10th Coat will Tell, if they do coat still beautiful & even = its the good Lead Color but of lighter hue than previously obtained with Big lot Chlorine in Copper)

Stuck to drum bad –

267 We try it again with a Copper drum – Buffed – The idea being that in 266 there was too much free Chlorine & that now the Iron is all passivated & the Chlorine Combined with the Copper So perhaps it will not stick This is the worst stick sheet we ever had Could not get first Coat Copper off at all Even with a Knife This shows It was cathodic – KOH That too much Chlorine in Copper makes 1st Coat Stick on Cobalt –

The next thing to try is to get CP Copper Anodes & Solution

and see if the good plating obtains
+ no chlorine is necessary = If it
sticks then - then perfect plating
will not answer, but the impurities
must be in to permit of stripping
Easy =

Any Copper Solution getting
in under 1st Coat Copper
Eats & Rots in the prime
Coat of Cobalt
The reason why the Cobalt at
Edge of Rubber Band was
Eaten down was probably
due to Copper Solution
not Being washed out under
Band.

268 –

We now try plating with Zinc from double Chloride of ammonia & Zinc, on a Copper 1st Coat over Cobalt drum —

Used Cobalt solution we set aside day before yesterday, but Chlorinated it with 2 Carbons 4 amp 3 minutes —

Plated Cobalt over 1st layer Copper — 18 amp 1 min than Zinc 15 amp 1 minute 100 on —

The Zinc Sol was made by dissolving Zn hydrate in Chl Ammon Can't get strong solution this way

Watts gives Chloride Zinc Chlorinated I guess —

On 4th Co deposit itself stripped as a whole + dropped down —

269 = Made Solution Chloride
Zinc 1.079 Spec. g — Reduced the
specific gravity somewhat by
adding Water. There was not
Enough solution to fill jar —
probable S. grav 1.1 25° or thereabout
This is Comed Chl Zn but very
white or I think not much
iron in it =
Plated drum after Cathoding
— KOH to clean it — with the
Reg 1st Coat in plain alk Cop
solution no Chlorine in it —
Zn plated on Copper 12 amp. 1 min
Cobalt on Zn : 18 amp 1 min rus on
1st Coat zinc blue and apparently OK
1st Coat Cobalt only fair, not even
probably due to poor Copper plating
or acid of Co solution attacking + gassing
Zinc — 2nd Coat Zn not very good,
Stopped at 6 layers Co got too
bad — strips OK —
plating not so bad —

270 – Duplicate of 269 –
Except 5 cc Chlorine in
Zinc Chl Solution –
Its plating a little yellow
Ng – stuck to Cylinder Bad
Zinc only powdery –
Chlorine made it stick like
it did when I used too much in
the Copper solution –

271 = Sulphate of Zinc, Specific G
1.150 – Coopers Sulphate, dissolved
distilled Water & filtered nothing
Else done Think it full of iron –
Coppered drum 1st after Cathoding
in KOH –
1st Coat Zinc good = 1st Co not perfect
black specs at places –
4 Coats Ng – stuck tight on
drum Coulent get it cut off.
Why? – Used Reg Copper bath
that we used all day that
came off fine –

272 We now use the Co solution
old one not the good one same as
used — 270 — a good Copper
sol we used today a use —
Lead-Antimony alloy — used
Rubber ring — Polished Copper
very used — got fresh solution
from up stairs which we
are now using but its just
as acid — 7 layers Co —
Came off ok except 2 spots where
1st layer Copper stuck & adjacent
layer Co came with the sheet
also the sheet pulled out holes &
of pieces of lead leaving Cylinder
plated terribly —

273 = We made a cylinder of pure
lead used baths same as in 271
plated good — 7 layers —
Came off at all stages
perfectly to lead —

274 – finding that Copper dont stick to 90 Lead 10 Antimony but sticks Lead to Lead alone I concluded that what is wanted is Antimony drum – Couldnt make it of Pure Antimony on account of Crystalization so I tried another piece of 75 parts Antimony 25 parts Tin to lengthen it – found button very hard brittle but without blow holes where chilled & took a beautiful polish – tried plating Copper on it beautiful Coat had no sticking properties whatever came off as flake –

I find this alloy does not self reduce the Copper Sulphate Sulphate – hence deposit is a true plating

tried plating Cobalt direct it also dont stick, it peeled itself

Fred Ott succeeded in moulding a drum by putting alloy in mould of Heat Cooling Cobalt plunging in Water. Shell was oval so in Turning it up he had to go below the chill where it is Crystalline - The drum also has pits from the surface because he was afraid to turn off too much. However the major part of the surface is good. When we get a good mould think can get fine results. Alloy does not show any tendency to have pin holes. The alloy is so hard that the Sheet can be cut off just as with Cobalt and fade if edge of knife is thin & sharp and will turn the Edge before cutting much of any -

Possibly we can use 66 Nickel & 33 Tin & give no more marqui-

275 - Made an alloy of 50 part Antimony and 50 parts Tin
This is quite hard and will strip as well as the 75+25 and is very brittle. —
You didnt try it — I did + Copper sticks —
Edison
You tried your own mixture
Forgive me — E —

276 = Made a Solution of 50 cc Water 100 CC HCl Concentrated 200 grammes Tartar Emetic I dissolved ok by stirring + gentle warming - it fellow very slow so gave it up but showed Geo fellow
Used small Lead drum plated with Copper + palmed —
put drum in Solution of Antimony with 2 amp it fell to 1½ in ½ minute - ~~to~~ Reversed Current for 5 minutes - plating like plated steel, beautiful but some large round warts

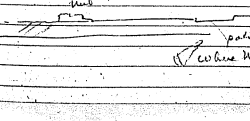
these could be broken off by edge of knife left no hole but a break in surface — The solution is as thick & viscous as Conc. Sulphuric acid and when put drum down probably took air & solution was so viscous they wouldnt leave cylinder — I diluted the solution about 1/8th by adding a solution of 1/2 pts water to 1 of HCl — pouring the thick solution in the $H_2O$ HCl solution & not the opposite — The above drum had 1st Coat put on the moment I started to cut it broke clean across & jumped off the drum perfect not a nob on inside — Even the Cobalt which had more solution than Copper & plated higher up & directly on the Antimony came off perfect possibly 1st Coat Copper not necessary WE are now going to plate a drum with the very thick Coat of Antimony to see how

thick we can go before it cracks & peels off itself —

277 = Started plating Aluminum from the thinned down solution. Whole drum immersed worked ok for 4 minutes at 2 amp then specs appeared ~~on~~ in 5 minutes. Most of specs under microscope shows flat & not round nobs as previous experiments — by using edge of knife they come off & show good surface of aluminum beneath so they must be due to gas. We now polish the Sb deposit up to remove the knobs & replate to see if it goes bad again in 5 minutes. If it don't possibly there are fine holes or bad places on the copper. Tried unpolishing removing 1 or 2 spots clean down to the copper — Tried silver drum but same knobs appeared —

I notice Anode gases at
2 amp on Silver dishes & by
stopping drum covered see
a few gas bubbles on drum
The Solution is also getting
full of ~~[illegible]~~ specks — the
Anode no Blue — a brown
dust is appearing — there should
be 6 strips in place of 2
Cathode should make these —
also ask Lyseley to test
the Antimony ~~for~~ tell him about
the brown mud —

The Silver plated drum was
left for Cooper to put out
came out of the solution —
lots big nubs plated up for
14 minutes. 1 @ 1½ amp —
when nub is broken off there is
a pitted surface below



This shows its not a hole — but dirt deposited — that made high resistance through it — the high rate made a large mub — if it was good can't see why they should be — if dirty but it may be good —

We filter the Solution all night in the morning the solution makes 4 more and output in Vessel 2 amp 4 run. Annull chrome until you get mubs see how many amperemuncles you go before mubs appear you can stop Wash & keep current on to see this! — Daily will plate the bells chrome all night with copper. —

~~Dont use anything wet~~ ~~put it in the Antimony solution~~ ~~the Water turns solution white~~ ~~by decomposing it~~

Dry the drum with paper perfectly dry before putting in Antimony solution —
Don't try to dilute the solution by water —

278 Took Cu plated drum and plated antimony at 2 amps for 18 min - Lots of nobs.

279 Took Cu plated drum and plated 15 min at 1 amp Still lots of nobs.

280 Plated drum 20 min at 350 miliamp not quite so many nobs

281 ~~Immersed~~ Cu drum into Sb ~~Sol~~ ~~and~~ reversed 5 min then turned on current plated 15 min @ 350 ~~mil~~ amp was about the same as 280

2-82 Reversed drum and put on current before immersing drum. then plated 15 min at 400 ma/d. – This was a little better

2-83 There is a white sediment falling to bottom of jar
Thread has not been a drop of water put in sol.
Reversed drum (at higher speed) turned on current before immersing
This made a great improvement

2-84 The white sediment is still increasing
Must find some way of doing away with the spots by treating solution, therefore I went back to old speed and treated sol by two ~~electrodes~~ electrodes 2 min at 800 MA. this did not improve plate very much

Jan 27-06

285 - Treated with carbon electrodes again 4 min @ 5 amps. This seemed to improve it some.
Plated 15 min @ 400 M.A.

286 Treated with carbon electrodes again and plated 15 min at 400 ma. This was very much better but still not fine

287 Now using a solution which Greenly made up. This gives a fine deposit like polished steel.
Plated 15 min @ 500 ma. but began to strip before removing from solution

288 Duplicated 287 this plating is fine.
I notice that all of our antimony plating is very easily removed from our copper cylinders evidently as

have got to find some thing to that will be more adherent for antimony.
When a Cu drum is plated with this antimony it will on standing begin to crack and peel. Evidently this is the eutectic variety.

289 Plated silver drum 110 min @ 500 ma
This has a fine polished steel looking surface

Jan 28-06

290 - Used antimony silver drum
Plated Cu 15 sec at 6 amps
then 2 min at 12 amps
Plated 7 coats then stripped
came off perfectly but
most all of the antimony
came off with it.

Tried 4 times to plate
antimony on silver but
was unable to plate it
more than 15 minutes at
6 amps after that it began
to peel.

Took the solution of $Sb_2S_3$ ~~and~~ dissolved in $K_2S$

Jan 29-06

Took Co plated drum and graphited it and plated $CuCo$ as usual.

1st series of plating came off perfectly

2nd series of plating came off pretty good

Examined drum surface under micro and found it very rough

Nickel plated another drum 1 hr at 4 amps then polished and graphited

1st series stripped fine

~~Plated~~ 2nd series without treating drum again

Dally is plating with 2 nickel drums grafitted, it catches up spots now & then but easily fixed — This is due to holes in the drum — 10 pm has 3 shots off — 10 ply — Hereafter he makes 7 ply —

No made 111.

There is 1 drum that had at top end this invariably tears there showing plainly that we must have drums with no checks, deep scratches or holes — All that the plumbago does is to fill tray & holes = Buffed drum wheel

I notice since we use plumbago there is no dirt or stuff between layers & also on the drum itself because the holes etc that held liquid are closed by graphite & oil

Assuming that the Cobalt bath runs ½ day (10) 5 hours between each Carbon Anodizing then on big Crack one ampere Continuously applied to Carbon Anode will keep bath in good order —

There is a trick in putting on graphite - If you get too much it will peel - if not enough it sticks
What you wanted is to fill the holes & deep scratches & remove all the rest without removing that in the holes
I guess if you fill & then (if it is too hard the wants goes down in the holes) wipe graphite out again
What wanted is cloth or Chamois - or a piece of hard leather that will not be springy enough to go down into a hole